A REVIEW OF RESEARCH AND EXTENSION LITERATURE ON THE USE OF ANNUAL LEGUMES IN ALTERNATIVE SUMMERFALLOW STRATEGIES IN THE BROWN AND DARK BROWN SOIL ZONES

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Prepared by:

Cyril Anderst, P.Ag.
P.O. Box 53
Hilda, Alberta
TOJ 1RO

My resource review was done in 1991 for the Alberta Pulse Grower's Commission (Zone 1 - southern Alberta). This association of pulse crop producers had two concerns on which they needed information:

1. The problem of post harvest wind erosion in pulse crop fields.

2. The challenge to the pulse industry to become involved in the use of legume crops in soil conservation generally and summerfallow replacement strategies, specifically.

A report was prepared on each of these issues. My presentation at this workshop is a summary of the report on summerfallow alternatives.

My information was obtained from three primary sources:

1. Researchers
   - Agriculture Canada (Alberta, Saskatchewan and Manitoba)
   - Northern Great Plains states (primarily Montana)
   - Other agencies such as the Crop Development Centre in Saskatoon and Chinook Applied Research at Oyen, Alberta.

   NOTE: Most information was obtained from the Swift Current (Agriculture Canada) Research Station.

2. Extension Personnel
   - Alberta, Saskatchewan and Manitoba Department of Agriculture.
   - Conservation specialists in the Prairie provinces.

3. Producer Groups
   - Conservation, crop and forage clubs in Alberta and Saskatchewan.

The report was structured under the following outline:

A. Concept of green manuring
B. Potential benefits
C. Disadvantages
D. Management methods
E. Other management criteria
F. Research (Prairie provinces)
G. Criteria for successful green manure cropping

A. CONCEPT OF GREEN MANURING

The conventional definition of green manuring describes it as the practice of planting some type of crop, usually a legume, on land that is to be fallowed and then plowing that crop under in midsummer.

Various management methods have been undertaken within this definition but the basic concept and purpose remains the same: soil quality renewal and improvement through the use of legumes.

The report focusses primarily on research done in the brown and dark brown soil zones since they stand to benefit more substantially due to their low natural levels of organic matter compared to black and grey-wooded soils

It is an unfortunate irony that green manure legumes have performed worst where they are needed most, while performing their best where they are needed the least. This is due primarily to precipitation differences. The challenge before the research community has been to develop a green manuring crop and management approach which will perform reasonably well under semi-arid conditions; that is, in the Palliser Triangle.

B. POTENTIAL BENEFITS

1. Increased soil organic matter levels.
   - serves to increase microbial activity in soil which, along with organic matter and soil nutrient production provide the "glue" which holds soil particles together.
   - Improved soil tilth (structure) makes it more mellow and less prone to crusting
   - Greater soil porosity and ability to absorb and hold water
   - Long term replenishment of organic nutrient (primarily nitrogen) reserves in the soil.

2. Nitrogen fixing capability of legumes
   - Serves to improve yield and protein content of subsequent cereal (grain) crops

3. Easily decomposable plant fibre

4. Soil surface coverage for protection from wind and water erosion

5. Contributes to the interruption of disease, insect and weed cycles, as is often the case when there is break from monoculture cropping.

6. Possible contribution to arresting the growth of saline seeps

7. Emergency source of high quality feed
   - caution regarding the growth stage at which certain legumes are cut for feed.

C. DISADVANTAGES

1. High seed cost
   - Important to allow a portion of the legume crop to grow to maturity for the purpose of seed retrieval

2. Poor weed competition

3. Lower flexibility in chemical weed control
   - Not a wide choice of pre- and post-emergent chemicals registered for use in legumes and those which are registered often have a narrow range of weeds which they control or are limited in the number of legume varieties upon which they can be used.

4. Consumption of soil water during growth period prior to plowdown or dessication
   - Underscores the need for green manure crops having a high level of water use efficiency
   - Important to include snow-trapping techniques in management

5. Crop establishment difficulties if moisture or heat stress exist
   - Important to plant early enough in spring to take advantage of better moisture conditions
   - Field pea and related species are able to germinate and begin growth under lower soil temperatures than are cereals
   - Legumes such as lentils can withstand a killing surface frost and initiate re-growth

D. MANAGEMENT METHODS

1. Plowdown - Snowtrap
   - Soil incorporation normally at full bloom using a disc implement.
   - Leave a quarter to a third of the plant matter visible on the soil surface
   - Leave a barrier strip of crop stand for snow trapping and extra wind protection

2. Undercutting - Snowtrap
   - Physical dessication by mechanical undercutting to stop plant growth and control weeds
   - Anchoring plant top material if blading operation leaves it lying too loosely on the soil surface
   - Leave barrier strip

3. Temporary chemical dessication - Snowtrap
   - If weeds are not a serious problem, a light application of 2,4-D will halt plant growth and prevent seed formation
   - Undisturbed crop serves as a snow trap

4. Complete chemical dessication - Snowtrap
   - If weeds are a problem, spraying with heavier concentrations of herbicide or straight dessicant
   - Remaining crop stand serves as a snow trap

5. Early tillage - Late seeding - Snowtrap
   - Cultural weed control until late June (approximately two tillage operations)
   - Seed legume crop and allow it to remain standing as a snow trap
   - Consider crop insurance implications: Will such fields still be granted "fallow" status for the next crop?

It must be noted that if the green manure crop is not soil incorporated, there will be a considerably lower release level of nutrients into the soil because plant top residues remain on the surface.

E. OTHER MANAGEMENT CRITERIA

1. Proper inoculation
   - Use correct strain of Rhizobium bacteria
   - Water use efficiency and dry matter production can be improved by a multiple of 2.3 times ($130^{o}/_{o}$) simply by using seed inoculant

2. Early seeding
   - Utilize more abundant topsoil moisture for better germination and more uniform plant growth and soil coverage

3. Fertilization
   - On fields testing low in available nutrient, a low level of supplemental nitrogen with the seed may be beneficial in ensuring stronger seedling development prior to the entry of inoculant bacteria into the plant root hairs.

4. Weed control
   - Pre-seeding weed control usually necessary to reduce or eliminate moisture competition in the early stage of crop growth.
   - If adequate weed control is not undertaken, earlier plowdown/ dessication is the only option in order to prevent weeds from going to seed.

5. Companion Crops
   - If part of the legume crop will be used for feed, seeding a low percentage of a cereal crop with the legume will not only provide a strong vertical support structure for the legume vines but will also add a higher energy component to the feed.
   - A higher standing crop in the barrier strips will also improve snow trapping.

6. Timing of plowdown/dessication
   - Best at full bloom, 6 to 8 weeks after emergence, the growth stage at which vegetative growth and nitrogen fixation synchronize at an optimal level.

7. Barrier Strips
   - Leave a strip of crop standing during plowdown or do a complete plowdown and plant barriers. Mustard was used for this purpose in one series of experiments at Scott, Saskatchewan.

8. Soil fertility monitoring
   - Annual soil testing over several consecutive years will help determine the actual "legume benefit" in terms of enhanced organic matter and nutrient levels.
   - Hand-inspecting topsoil while taking soil samples will also give a visual and tactile comparison of soil mellowness from year to year.

9. Cost/benefit monitoring
   - To test the short term economic viability of the green manuring practice, its attendant costs must be compared to those of conventional summerfallowing, plus the cost of fertilizing the next crop.
   - Long term costs and benefits must also be considered, including a comparison of the yield and quality of cereal crops in the years following green manure versus conventional fallow.
   - The bottom line is whether the short term cash costs are acceptable when weighed against the longer term benefits.

F./G. RESEARCH (Prairie Provinces)/CRITERIA FOR SUCCESSFUL GREEN MANURE CROPPING

Probably the most extensive investigation of green manuring in the brown soil zone has been done at the Agriculture Canada Research Station in Swift Current. Seven years of crop selection, field trials and data collection have centred primarily on four legume crops:

- Indianhead Black lentil
- Tinga Tangier flatpea
- Semu-SI (Sirius) feed pea
- NC8-3 Chickling vetch

Several researchers have outlined a list of at least seven requirements which an annual legume crop ought to meet in order to be an effective green manure. Some of the legumes listed above meet most of these requirements quite favorably, but not all of them are outstanding in each and every one. It would be unrealistic to expect that to happen. The desired features are as follows:

1. Fast emergence to provide early ground cover.
   It was noted by one research scientist that the Chickling vetch seed absorbs water rapidly thus enhancing its ability to germinate under low moisture conditions.

2. High rate of plant matter production.
   The average dry matter production by these legumes was found to be 1950 lb./acre. The Sirius feed pea and Chickling vetch scored highest with 2640 lb./acre and 2190 lb./acre respectively.

3. High nitrogen fixing capacity.
   The average amount of fixed nitrogen in plant tops and roots of these four legumes was 44 pounds per acre. The Sirius feed pea and Chickling vetch contained 51 pounds and 63 pounds of fixed plant nitrogen respectively.

4. High water use efficiency.
   A three year water use average for these four legumes was 637 pounds of soil water consumed to produce one pound of dry matter. Once again, the Sirius feed pea and Chickling vetch were well under that average at 480 pounds and 534 pounds respectively.

5. Readily digestible, high protein feed.
   In vitro digestibility of the four legumes found them to be roughly equal to the average of 72.5 percent digestible organic matter with the feed pea ranking best (74.9%), black lentil second (73.9%), vetch third (71.1%) and flat pea last (69.9%).
   The average protein content of these legumes was 17.5% with the vetch highest at 18.9% and the feed pea lowerst at 15.2%.

6. Resistance to insect attacks.
   The Tangier flatpea was highly susceptible to insect attacks and frequently suffered foliage losses of up to one third due to foraging by grasshoppers and blister beetles.

The Indianhead lentil suffered some damage from grasshoppers, but much less extensively and less frequently compared to the flat pea.
The Chickling vetch was moderately resistant to insect attacks.
The Sirius feed pea not only demonstrated a total resistance to insect attacks, but even exerted a strong repellant effect on grasshoppers.

7. Ability to compete primarily with broadleaf weeds.
None of the legume crops demonstrated strong competition with weeds.

Of these four legumes, the Indianhead lentil is the only one which is officially registered for green manure applications in the Canadian Prairies. It was registered in 1986 after research and development by Dr. Al Slinkard of the Crop Development Centre here at the university.

Emerging from the work at Swift Current is a strong endorsement of the Chickling vetch which could join the Indianhead lentil as another viable legume plowdown crop in Western Canada. The vetch stands out in its singularly high capacity for nitrogen fixation and excellent drought tolerance. This was borne out by research from 1985 when May-July growing season precipitation was only 44% of the historic average at Swift Current. Chickling vetch was the only legume which did not wilt or shed lower leaves. Its roots showed more extensive nodulation throughout their entire length and not just in the crown area. The vetch also displayed aggressive nodulation under moist conditions in 1986 when the dry weight of its nodules was 50% of the total root weight compared to the normal proportion of 15% for most annual legumes. Because it is still an experimental crop, the Chickling vetch will not be commercially available until it is officially registered.

The Sirius feed pea, with its favorable feature for green manuring, is another option worth considering.

H. MISCELLANEOUS

Despite the potential benefit of green manuring, a number of points must be considered to keep one's thinking on a realistic perspective.

a) Green manuring, like other innovative management practices is not a cure-all for the negative forces upon our soil. Its success in terms of growth and nutrient generation still depends ultimately on the weather, more specifically rainfall, during the growing season. Dr. "Bix" Beiderbeck stated it correctly when he commented that the need in the Brown and Dark Brown soil zones is for a green manure crop which will perform well in all years in the southern Prairies and not just in the wet years (such as 1986 and 1991) which are the exception rather than the rule.

b) Producer and extension personnel commentary suggest that the practice of green manuring in any form as a fallow replacement excercise has a long way to go before it will gain wide acceptance in the Prairie provinces. Because of financial and agronomic demands (e.g. soil water loss, weed control, etc.), the immediate cash costs tend to outweigh the benefits no matter how real and

substantial they may be. Short term stress on the pocket book tends to blur the vision of longer term benefits.

c) Because of the previous two points, producer who are hesitant to try out this practice must be encouraged to start out on a small scale in order to develop a working knowledge of its costs, management and benefits. It could be attempted as a field demonstration project through a government-sponsored conservation program.

d) The research community has responded well to a very real soil quality challenge in the Brown and Dark Brown soils. Developing quality crops which produce high levels of plant matter and fixed nitrogen, maintain high water use efficiency and possess other end uses is certainly the correct course to follow.

FINAL NOTES

a) The literature review which culminated in the report on green manuring was fairly extensive but is by no means put forward as an exhaustive collection of all pertinent material on this matter.

b) Because of the brief format of my presentation on this report, some segments of it have been omitted in these proceedings, such as research information out of Montana and alternate end uses for annual legumes (e.g. animal feed, human food products).

c) All of the material contained in this presentation has been taken from the report entitled "Pulse Crops as Summerfallow Alternatives", dated November 27,1991.